discussed, he will admit that his points are well argued and that the book has given him a clear outlook upon the broad subject of municipal works.

GEORGE C. WHIPPLE.

DISCUSSION AND CORRESPONDENCE.

ELECTRICITY AT HIGH PRESSURES.

TO THE EDITOR OF SCIENCE: Some three or four years ago* I put forward the idea that just as with increase of vacuum and potential the Roentgen rays become more and more penetrating, there may possibly be produced, when cathode ray ions (electrons) move with the very highest velocities, rays that penetrate considerable thicknesses of nearly all bodies without undergoing absorption. Interstellar space may be traversed not only by light and heat waves, but also by rays of the more recently discovered penetrating kinds including those of extreme penetrating powers above assumed as possible.

From what source would such highly penetrating rays as are referred to come? Might they not come from matter (electrons or assemblages of electrons called atoms, or even small masses of matter) moving with such very high velocities as are somewhat comparable with the velocity of light? These assemblages of electrons on impact would probably give Roentgen rays of all orders up to the very highest or most penetrating. Such rays would be absorbed only in larger or denser masses of matter and the absorption would ordinarily be undiscoverable. The celestial bodies, as the stars, planets, etc., would probably absorb the rays, and the rays in being so absorbed would add energy to the masses, tending to some extent to keep up their temperature.

The natural question arises as to whether there are any existing conditions under which the smallest particles could attain high velocities. When an extremely minute particle of matter near the sun or in the outer envelope of gas around the sun is of a nature to absorb the radiation, a radiation pressure will be exerted upon it which may, if the particle is small enough, be in excess of gravitational force. Such particles continuously expelled, in virtue of the excess of radiation pressure over gravitation, may give rise to the coronal streamers around the sun. If the condition just pointed out be possible, the particle will, under the difference of force, be accelerated outwardly from the sun, and continue to move away with an acceleration which, though diminishing, is still an acceleration. Such particles would naturally be expected to leave or be driven away from any hot star.

That a particle once started away will continue moving outwardly with an acceleration, follows from the fact that both the radiation pressure and gravitation vary as the inverse squares of the distances. This means that if a particle is moving towards the sun under the influence of gravitation, it will not at any time be stopped by the radiation pressure unless it be subdivided into smaller particles. It also means that any set of particles moving from the sun under radiation pressure in excess of gravitation must continue forever moving away, unless such particles are brought together into large masses or collide with other masses. It is possible that the limiting velocity which could be attained would be the speed of light waves in the ether. Such rapidly moving particles, whether consisting of many molecules or atoms (groups of electrons) or consisting of separate electrons or ions would probably, on striking other particles or masses, give out intense radiation of the Roentgen ray order, and accompany the same by heat radiation, or visible radiation, or both. Such particles might even serve to illuminate some of the apparently cold nebulæ, either by the impact generating heat and light, or by fluorescence.

Here, then, is the outline of a new corpuscular theory of energy conservation, which is not the Newtonian corpuscular theory, but which supplements the undulatory theory in providing a mode of recovery for at least a portion of the energy of radiation. Any particle which is set in motion by the radiation pressure is within limits converting the energy of radiation into mechanical move-

* 'Electricity at High Pressures,' lecture before the New York Electrical Society, March 29, 1899.

ment or moment, which movement continues until such particle meets an obstacle and the energy is again reconverted to heat, light and to those forms of obscure radiation, more or less penetrating to ordinary matter.

It is doubtful whether radio-active substances like radium are the fluorescent detectors of such rays as reach us from space, and which are not absorbed by our atmosphere. The simpler hypothesis is that of atomic instability. But the hypotheses which have been outlined above—and they are, of course, only scientific speculations or hypotheses as yet—naturally suggest lines of investigation which are desirable to be carried out. In that way only can any truth, if it exists in these ideas, be determined; or the ideas disproved, as the case may be.

Elihu Thomson.

A POSSIBLE USE FOR RADIUM.

On the authority of M. Curie radium is worth about one million dollars a pound. This estimate is based on the cost of isolating this rarest, newest and most wonderful of the metals, rather than upon its uses to practical people.

Utilitarians may demand: 'Of what use is radium?' Sir Oliver Lodge has said this is difficult to answer for people who wish to make money out of it, but although at present radium grinds no axes, it is held in great estimation by physicists who see in its amazing energy possible solutions for old problems and materials for new ones. A British writer in the *Daily Graphic* of July 13 points out one direction in which a study of the properties of radium may prove of the greatest benefit to mankind, and that is the analogy between its rays and those of luminous insects. As Sir Oliver Lodge remarks, if we could discover the secret of the fire-fly's power to convert some unknown source of energy into light, we could produce light without heat.

Hope is expressed that the study of radium may lead us to a method of obtaining light in a cheaper and more convenient manner than any now known.

X.

SHORTER ARTICLES.

THE FISHES OF THE AFRICAN FAMILY KNERIIDÆ.

In 1866 Dr. Steindachner introduced into the ichthyological system a peculiar western African fresh-water fish which he called *Kneria angolensis* and referred to the family Acanthopsidæ or Cobitidæ. Two years later (1868) Dr. Günther added another species from central Africa (*Kneria spekii*) and ranked the genus as the representative of a peculiar family—Kneriidæ. He placed it as an 'Appendix to the Cyprinidæ,' and there it has ever since been allowed to remain, but I have always felt convinced that it was not at all related to the Cyprinids or Plectognaths even. Very recently data have been acquired which may help us to a solution of the taxonomic problem.

In 1901 Dr. Boulenger made known a remarkable pigmy fish (30 mm. long) from the upper Nile (Fashoda) which he named *Cromeria nilotica* and referred to the family Galaxiidæ, thinking that it 'appears to be most nearly related to *Galaxias*.'

It is very unlikely that the tropical fish should be a member of a family all of whose certain representatives are characteristic of the cool and cold waters of the southern hemisphere and I was inclined to believe that it was really related to the Kneriidæ. An important paper just published by Dr. Swinnerton appears to confirm this view.

In the *Zoologischer Jahrbücher* (Anatomie) published in June, 1903 (pp. 58–70), Dr. Swinnerton has given an article on 'The Osteology of *Cromeria nilotica* and *Galaxias attenuatus*' and made known some extremely interesting results. It appears that there is no relationship between *Cromeria* and the *Galaxiids*, and that *Cromeria* belongs to a peculiar family remarkably distinct from any other known unless it be that of the kneriids. To that, indeed, it seems to belong. It has the same general form, the same arrangement of the fins, the projecting snout or upper jaw, the toothless trenchant jaws, the absence of pharyngeal teeth, the three branchiostegal rays, the very narrow branchial apertures, and the simple air-bladder. Indeed, in all essential